

NE 4th Street and NE 8th Street Corridors Evaluation Report

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Executive Summary

The project evaluation focuses on developing improvement concepts for four intersections along two corridors:

- NE 4th Street Corridor
 - NE 4th Street and NE Revere Avenue
 - NE 4th Street and NE Olney Avenue
- NE 8th Street Corridor
 - NE 8th Street and NE Revere Avenue
 - NE 8th Street and NE Olney Avenue

Given the proximity to NE 3rd Street (US 20), both intersections at NE 4th Street were evaluated alongside those at NE 3rd Street to understand the influence of NE 3rd Street on NE 4th Street operations.

System Level Needs and Constraints

- Queues from NE 3rd Street and NE Olney Avenue intersections spill back into NE 4th Street and NE Olney in the future.
- Transit routes are planned along the NE 4th Street and NE 8th Street corridors and should be accommodated in any intersection design, including safe walking and biking access to transit stops.
- A section of NE Olney Avenue, west of NE 6th Street, has been identified as a Key Walking and Biking Route.
- NE 4th Street is part of the Bicycle Low Stress Network (LSN). NE Revere Avenue and NE Olney Avenue, west of NE 6th Street, are also part of the LSN.

Intersection Level Needs and Constraints

- There is limited right-of-way today at NE 4th Street and NE Olney Avenue due to retaining walls on all four corners of the intersection.
- There is limited right-of-way today at NE 8th Street and NE Olney Avenue due to retaining walls along the west leg and houses adjacent to the intersection.
- Both study intersections along NE Revere Avenue have an observed crash rate higher than the 90th percentile crash rate of similar sites in Oregon.
- Intersection operations at all study intersections, except NE 3rd Street and NE Revere Avenue, fail to meet City of Bend standards in the future (2040).
- Without additional improvements, 95th percentile queuing in the future (2040) is significant at all study intersections, with many queues spilling back into other intersections.

Recommendations

There is an overall budget of \$14 million identified in the General Obligation (GO) Bond for improvements to all four intersections. The recommendations below are expected to fit within the project budget.

NE 4th Street

Signals are recommended to be installed at the study intersections along NE 4th Street due to the proximity of NE 3rd Street (a signalized corridor that has high traffic volumes) and the need for enhanced pedestrian and bicyclist crossings. The high traffic volumes and congestion along NE 3rd Street are forecasted to cause queue spillback into the NE 4th Street intersections, particularly along NE Olney Avenue, and the queuing would impede traffic through a roundabout.

At NE 4th Street and NE Revere Avenue:

- Figure 1 shows the approximate intersection footprint. It is recommended along the north and south legs that an approximately 200-foot left turn lane be constructed to provide the opportunity for protected left turn phases. The east and west legs would retain their existing lane configuration.
- Figure 1 also includes an optional right turn lane on the north leg. This could be constructed if needed in the future to reduce queuing and/or to support implementation of a particular pedestrian or bicyclist crossing treatment.
- Enhanced intersection lighting is recommended at this intersection to address a history of crashes that occur in the dark, as identified by the Bend Transportation Safety Action Plan (TSAP).
- The signalized concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements. Figure 1 shows an example of how some of these improvements could be implemented but additional design and community feedback is still needed.

NW 4th Street and NW Revere Avenue Proposed Signalized Intersection

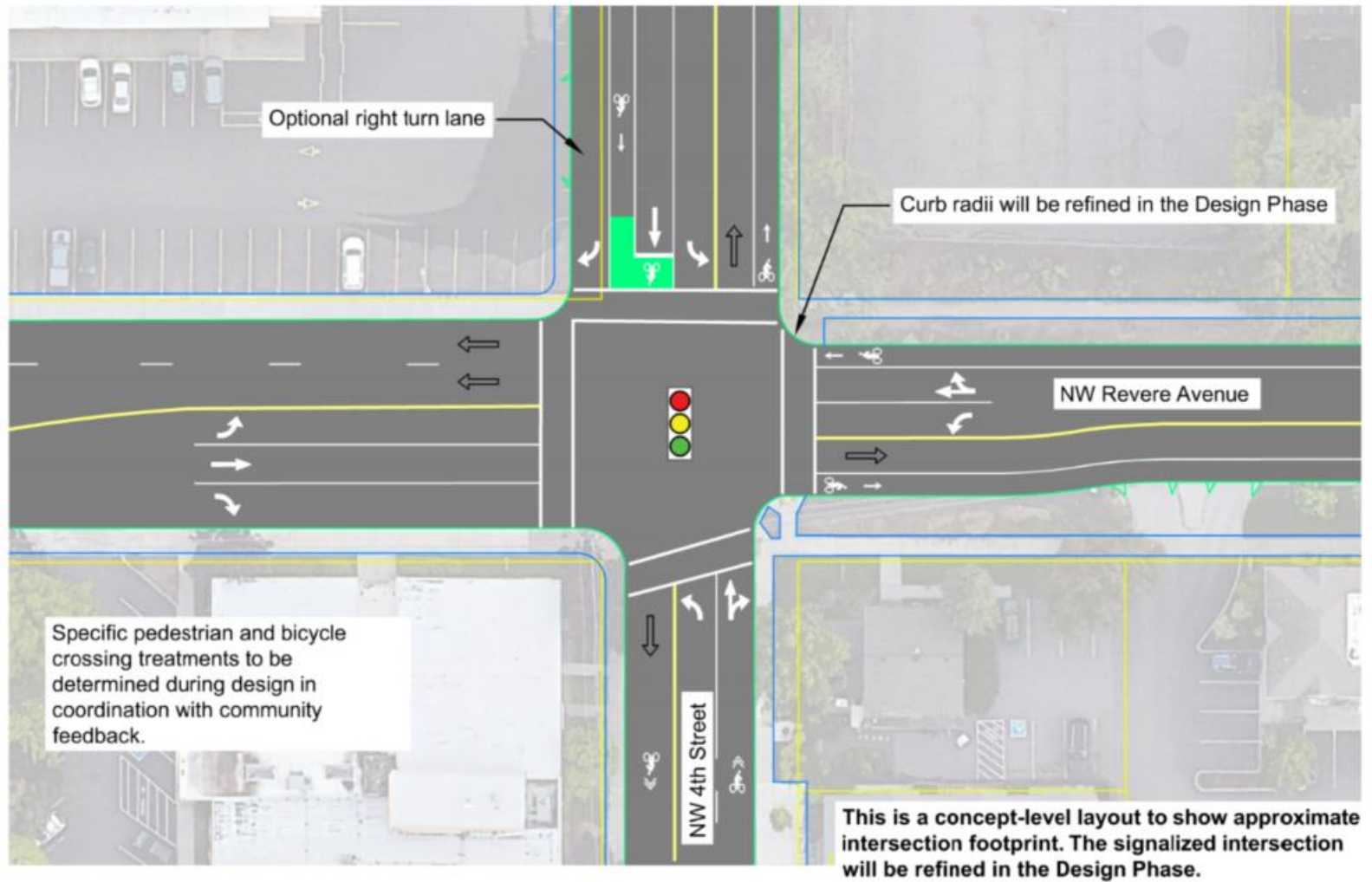


Figure 1: Proposed Signalized Intersection Layout at NE 4th Street and NE Revere Avenue

At NE 4th Street and NE Olney Avenue:

- Figure 2 shows the approximate intersection footprint if a signal were installed at this location. The east, west, and south legs of the intersection would retain their existing configurations. On the north leg, a 200-foot right turn lane is recommended to help address future queueing issues on 4th Street. While not needed in the near-term, the right turn lane will help provide queue storage in the 20-year planning horizon as NE 3rd Street congestion regularly spills back to NE 4th Street.
 - Given the right-turn lane is not needed in the near-term, the turn lane could be added in the future when needed to address congestion issue and/or to support implementation of a particular pedestrian or bicyclist crossing treatment.
- The signalized concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements. Figure 2 shows an example of how some of these improvements could be implemented but additional design and community feedback is still needed.
- As there is a CET bus stop near the NE 4th Street and NE Olney Avenue intersection that will be retained for Route 5, the intersection improvement should accommodate the stop somewhere near its existing location.

NW 4th Street and NW Olney Avenue Proposed Signalized Intersection

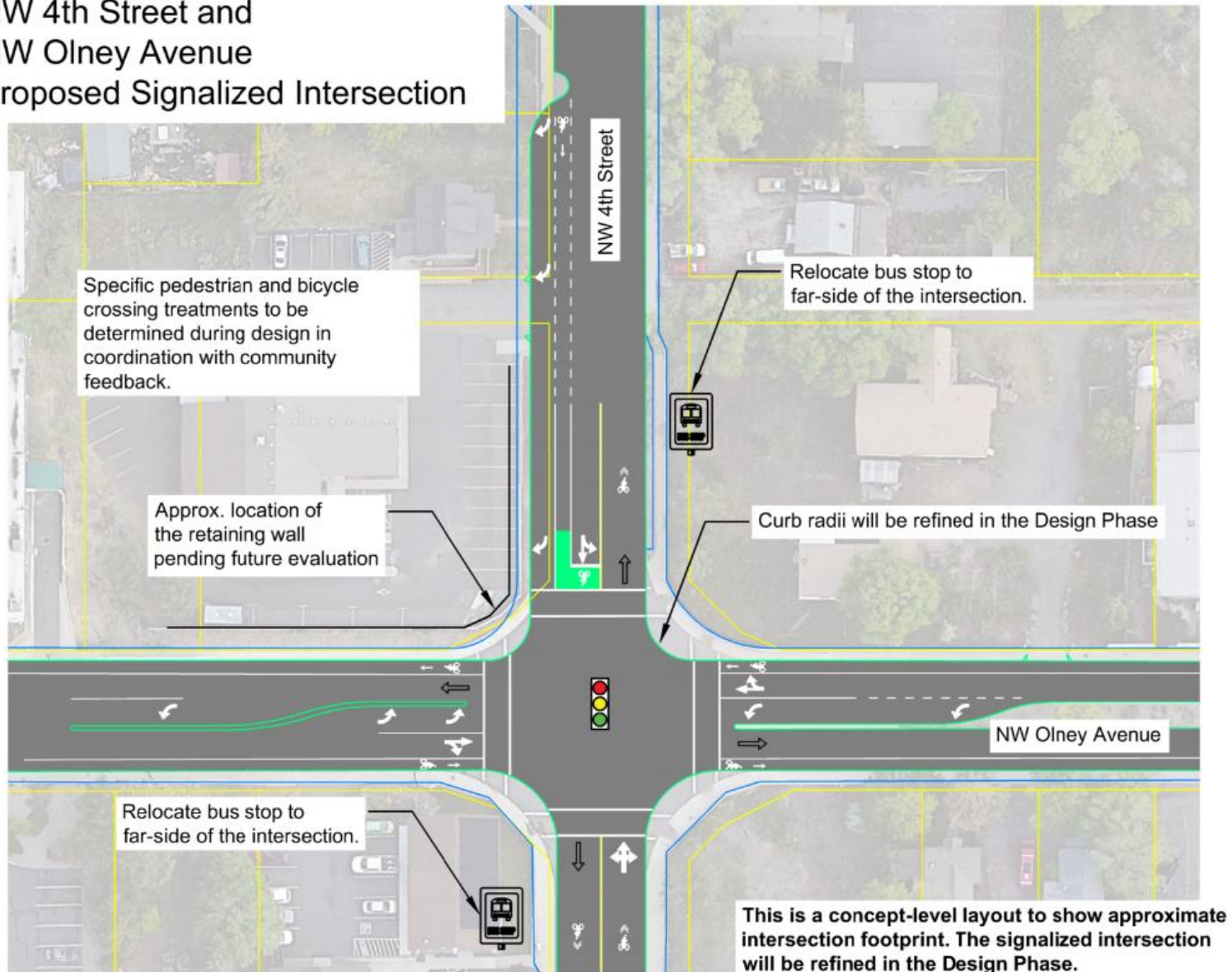


Figure 2: Proposed Signalized Intersection Layout at NE 4th Street and NE Olney Avenue

NE 8th Street

Roundabouts are recommended to be implemented at the study intersections along NE 8th Street due to improved safety and operational performance.

At NE 8th Street and NE Revere Avenue:

- Figure 3 shows the recommended roundabout lane configuration (single-lane roundabout).
 - The concept depicts a single-lane roundabout that is 130 feet in diameter, designed to accommodate WB-50 trucks, with 18-foot entry and exit lanes on all approaches and 14-foot offsets for sidewalk and buffer. The roundabout is shifted north to have as little impact as possible on existing structures on the southwest and southeast corners. This concept will continue to be refined during design to reduce potential right-of-way impacts.

At NE 8th Street and NE Olney Avenue:

- Figure 4 shows the recommended partial multi-lane roundabout with right turn slip lanes lane configuration.
 - The concept depicts a partial multi-lane roundabout with right turn slip lanes, shifted north to minimize southeast and southwest building impacts.
 - The concept shows a roundabout with 150-foot diameter that accommodates WB-50 trucks and has multi-lane entry on north, east, and west approaches, single 18-foot lane entry on the south approach, single 18-foot exits on all approaches, and 14-foot offsets for sidewalk and buffer. This concept will continue to be refined during design to reduce potential right-of-way impacts.
- NE 8th Street and NE Olney Avenue was identified as a top 10 percent site for equivalent property damage only in the Bend TSAP. A roundabout would improve safety at the intersection compared to the existing signalized intersection.

NW 8th Street and
NW Revere Avenue
Proposed Roundabout

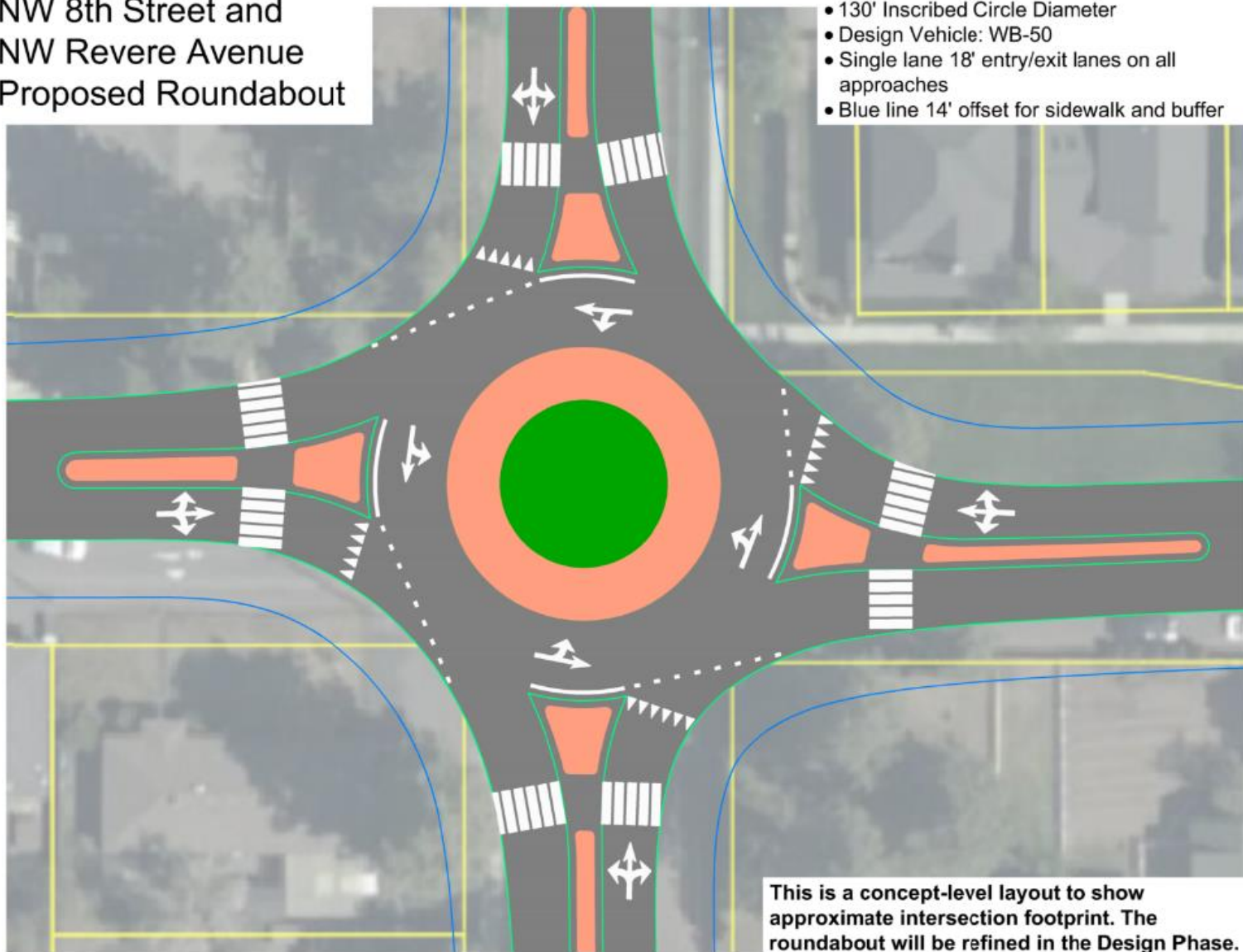


Figure 3: Proposed Roundabout Intersection Layout at NE 8th Street and NE Revere Avenue

NW 8th Street and NW Olney Avenue Proposed Roundabout

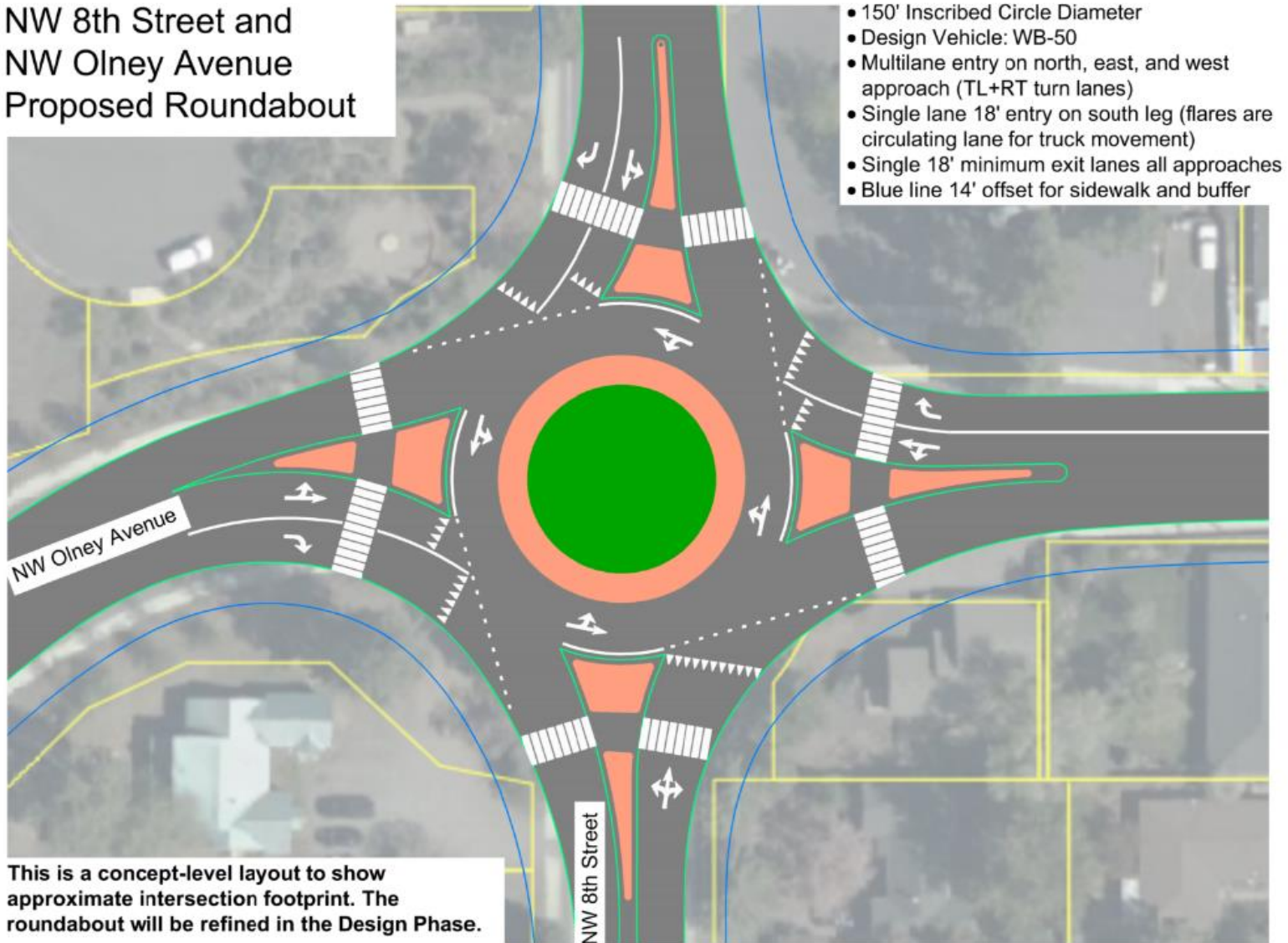


Figure 4: Proposed Roundabout Intersection Layout at NE 8th Street and NE Olney Avenue

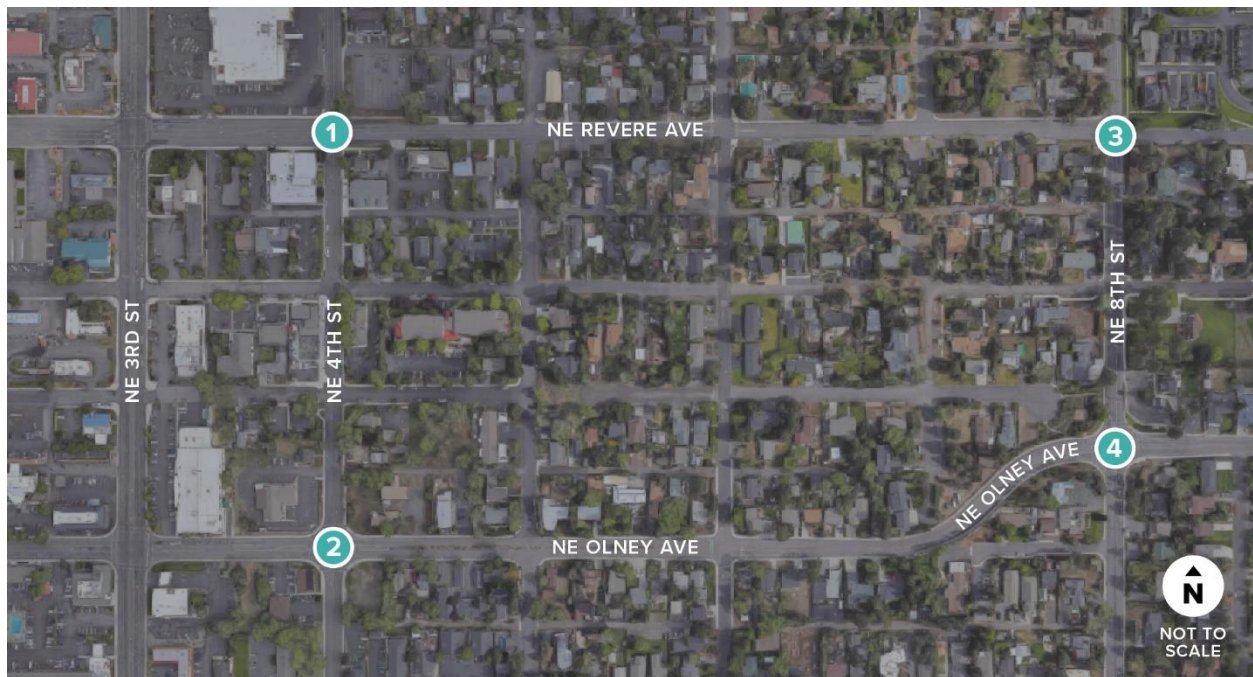
Project Assumptions and Background

This section documents key project assumptions and reviews and documents relevant plans, policies, and other applicable background information for the NE 4th Street and NE 8th Street corridor operations evaluation.

Study Area and Background

The project evaluation focuses on two General Obligation (GO) Bond projects: NE Olney Intersection Improvements and NE Revere Intersection improvements (at NE 4th Street and NE 8th Street). The study area, shown in Figure 5 below, includes four intersections, organized into two main corridors based on similar land use contexts in the area and proximity to NE 3rd Street, which is a signalized corridor:

- NE 4th Street Corridor
 - NE 4th Street and NE Revere Avenue
 - NE 4th Street and NE Olney Avenue
- NE 8th Street Corridor
 - NE 8th Street and NE Revere Avenue
 - NE 8th Street and NE Olney Avenue



Study Intersection

Figure 5: Study Intersections

Relevant Planning Document Review

This section summarizes information contained in relevant planning documents that pertains to the study area. Incorporating transportation infrastructure and services that are planned for the study area establishes consistency among planning documents and works toward achieving their respective goals.

Bend Transportation System Plan

The Bend Transportation System Plan (TSP) establishes transportation system changes for current and future growth in population and changes in land usage through the year 2040. With that plan, a section of NE Olney Avenue in the project area has been identified as a Key Walking and Biking Route. NE Revere Avenue, NE 4th Street, and a section of NE Olney Avenue are part of the Bicycle Low Stress Network (LSN). See Figure 6 for excerpts of the maps from the TSP.

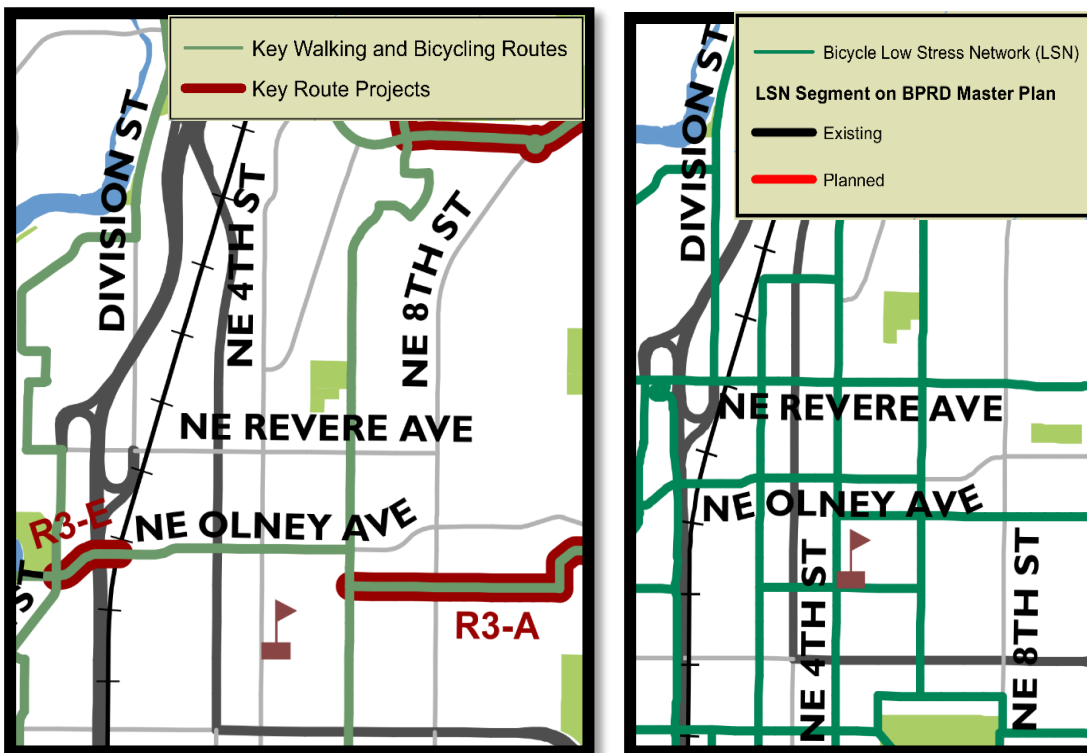


Figure 6: City of Bend TSP Key Walking and Bicycling Routes and Bicycle Low Stress Network
 Source: Bend Transportation System Plan, Figures 5-1 and 5-3b

The TSP identified four intersection improvement projects that are relevant to this project evaluation report:

- C-15: NE Olney Avenue / NE 8th Street intersection improvement – improve intersection capacity
- C-16: NE Revere Avenue / NE 8th Street intersection improvement – improve intersection capacity
- C-28: NE Revere Avenue / NE 4th Street intersection improvement – improve intersection capacity

- C-29: NE Olney Avenue / NE 4th Street intersection improvement – improve intersection capacity

Additional projects under Key Walking & Biking Routes & Associated Capital Improvement Projects that are relevant to this project evaluation report include:

- R3-A: Norton Ave: NE 6th St to NE 12th St – Neighborhood greenway: Create a low-stress bikeway on NE Norton Ave.
- R3-C: Neff Rd: NE 12th to Big Sky Park – shared use path adjacent to roadway; close sidewalk gaps and create a low-stress bikeway.
- R3-E: Olney Avenue: Wall Street to railroad – shared use path adjacent to roadway; close sidewalk gap over railroad and remove existing barrier to east-west bicycle connectivity and create right-turn hook crash countermeasure.

Given there were no specific recommendations for how to improve intersection capacity in the TSP, this analysis will inform a recommendation for intersection capacity enhancements at each of the four study intersections that are compatible with the TSP LSN and Key Walking and Biking Route designations.

Cascades East Transit 2040 Transit Master Plan

The Cascades East Transit (CET) 2040 Transit Master Plan (TMP) summarizes the transit services provided by CET for Central Oregon, including the City of Bend. The plan is used by CET to identify future services and how funds are spent.

Routes 5 and 6 travel along NE 4th Street, but only Route 6 has a stop located adjacent to the study intersection of NE 4th Street and NE Olney Avenue. The following summarizes the changes planned to Routes 5 and 6 in the future:

- In the short- to mid-term future, Route 6 is planned to be rerouted, while Route 5 would continue to service NE 4th Street.
- The existing Route 6 bus stop located near the study intersection will most likely become a Route 5 bus stop. Regardless, it will be necessary to maintain or replace the existing bus stop when the intersection improvements are constructed.

Proposed Route 8: Service to northeast Bend is planned to travel along NE 8th Street to connect northeast Bend to the primary transit network. This Route is needed due to the existing demand along Route 4 that serves Juniper Ridge. The goal identified in the TMP is to initiate a microtransit pilot to test demand and build an understanding of traffic patterns for a potential new fixed route. The following summarizes the proposed Route 8 changes:

- In the mid-term (2030) to long-term (2040), CET is planning to provide a new route connecting northeast Bend to NE 8th Street and Boyd Acres Road, serving Cascade Village and/or Juniper Ridge, as well as downtown and Hawthorne Station.
- This is expected to eliminate the need for Route 4.

Any intersection improvements recommended as part of this project should accommodate existing and future planned transit service along NE 4th Street and NE 8th Street while providing safe walking and biking access to transit stops in the area.

Bend Area Transportation Safety Action Plan

The Bend Area Transportation Safety Action Plan (TSAP) is the City's specific action plan that was developed to aid the City and partnering agencies in protecting people traveling within

Bend from injuries. The TSAP evaluates crash trends and issues based on current data and identifies a broad range of treatments including projects, policies, and programs to address identified issues. Relative to the study area for this memorandum, the TSAP identifies:

- NE 3rd Street and NE Revere Avenue intersection is listed as part of the top 25 sites for safety improvements.
- NE 4th Street and NE Revere Avenue intersection is a top 10 percent site in the City for equivalent property damage only (EPDO) scores (a measure that considers both collision severity and frequency).
- NE 4th Street corridor north of the NE 4th Street and NE Revere Avenue intersection is a location for Excess Dark (No Lights) Collision Sites and in the top 10 percent site in the City for equivalent property damage only (EPDO) scores (a measure that considers both collision severity and frequency).
- NE 4th Street corridor as having a bicycle level of traffic stress 1 (indicating a safe and comfortable bicycling environment).
- NE 8th Street corridor as having a bicycle level of traffic stress of 3 and 4 (indicating a stressful bicycling environment)
- NE 8th Street and NE Olney Avenue is listed as a top 10 percent site in the City for equivalent property damage only (EPDO) scores (a measure that considers both collision severity and frequency)
- NE 8th Street and NE Revere Avenue is identified as an Excess Angle Collision Site

No specific projects, policies, or programs were discussed to address the issues at the study intersections in this memorandum.

Analysis Methodology

All analysis was conducted based on methodology documented in the methodology memorandum¹. There were several alternatives analyzed for each of the study intersections to improve the overall corridor.

Additional Assumptions

The findings and recommendations enclosed in this project evaluation report are based on the following assumptions:

- Planning-level intersection concepts are included as part of the alternatives analysis (representing less than 10 percent design).
- The traffic analysis reflects the PM peak hour, as it was observed to be higher in motor vehicle volume than the AM peak hour. Traffic volumes along NE 8th Street were adjusted for the analysis, as field observations completed in March 2022 found an increase in congestion along the corridor compared to the date the counts were taken.
- All the roundabout concepts considered WB-50 or WB-67 design vehicles (a semi-trailer truck).

¹ Go Bond Project Scoping: Draft Methodology Memorandum, January 17, 2022

Analysis and Operations Review

This section provides an overview of key findings and outcomes of analysis and operations of existing and future no-build conditions of the study intersections. It includes traffic operations, crash history, pedestrian and bicyclist network, and access analysis. The purpose is to identify and confirm needs that should be addressed by the preferred alternative.

Existing Intersection Operations

The existing roadway characteristics near the study intersection are shown in Table 1. All four roadways had two travel lanes, sidewalks, and a posted speed of 25 mph.

Table 1: Existing Roadway Characteristics

Roadway	Functional Classification ^A	Posted Speed (mph)	Number of Travel Lanes	Sidewalks	Bike Lanes
NE 4 th Street	Collector	25	2	Yes	Sharrows, then bike lanes north of NE Revere Avenue
NE 8 th Street	Minor Arterial	25	2	Yes	Yes
NE Olney Avenue	Minor Arterial	25	2	Yes	Yes
NE Revere Avenue	Minor Arterial	25	2	Yes (North side of street)	Yes

^A From the City of Bend Transportation Plan Roadway Functional Classification Map.

Traffic Volumes

Turning movement counts for the AM peak period (7:00-9:00 AM) and PM peak period (4:00-6:00 PM) were collected on October 12, 2021. These counts included passenger vehicles, heavy vehicles, pedestrians, and bicyclists and represent average weekday conditions. Appendix A includes the traffic count worksheets. The PM peak hour for each of the study intersections generally occurred between 4:30-5:30 PM. Figure 7 shows the existing (2021 with adjustments) traffic volumes and lane configurations for each of the study intersections.

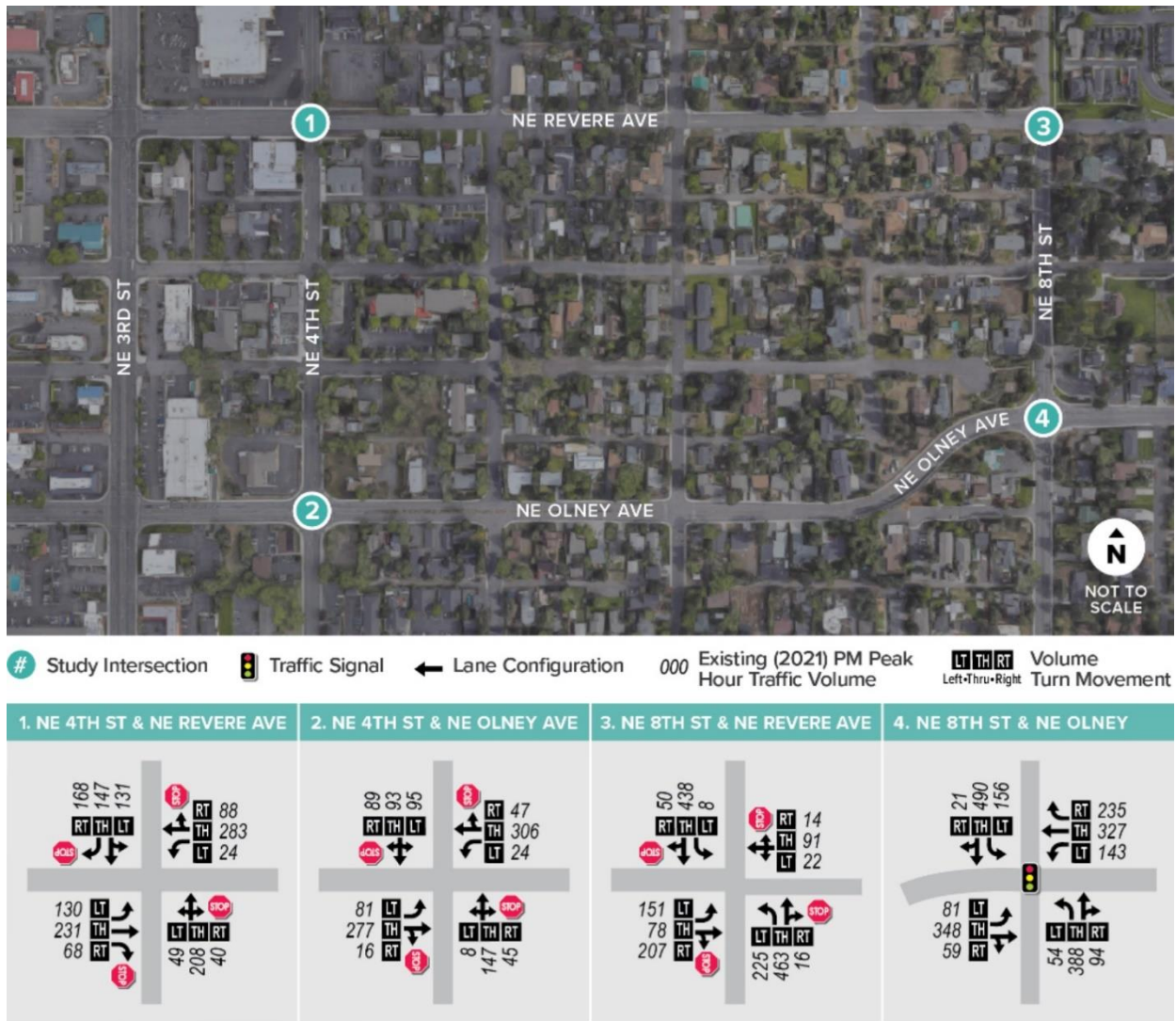


Figure 7: Existing (2021) Traffic Volumes and Lane Configuration

Intersection Operations Results

Intersection operations were evaluated at each of the four study intersections, as well as two intersections at 3rd Street at Revere Avenue and Olney Avenue. The proximity and high volumes of NE 3rd Street were found to affect the NE 4th Street study intersections. The PM peak hour conditions were then analyzed using the Highway Capacity Manual (HCM) 6th edition methodologies using Synchro software. Several performance measures are reported, including delay, level-of-service (LOS), and volume-to-capacity (v/c) ratio.

Table 2 shows the existing (2021) intersection operations for all six intersections, including NE 3rd Street. Both NE 4th Street and NE Revere Avenue, and NE 8th Street and NE Revere Avenue do not meet City of Bend mobility standards for all-way stop control intersections, with average delay exceeding 50 seconds. See Appendix B.1 for existing intersection operations.

The westbound left turn lane NE 4th Street and NE Revere Avenue intersection operates with a v/c of 1.15 while the southbound approach at NE 8th Street and NE Revere Avenue intersection operates with a v/c ratio of 1.18. It is likely that drivers at both intersections are likely entering the intersection more aggressively than Highway Capacity Manual 6th Edition defaults.

Table 2: Existing (2021) PM Peak Hour Intersection Operations

Intersection	Control ^A	Mobility Standards	LOS	Delay (s)	v/c
NE 3 rd Street & NE Revere Avenue	Signalized	≤ 0.90 v/c	C	30	0.70
NE 3 rd Street & NE Olney Avenue	Signalized	≤ 0.90 v/c	D	36	0.74
NE 4 th Street & NE Revere Avenue	AWSC	≤ 50s delay	F	130	1.15
NE 4 th Street & NE Olney Avenue	AWSC	≤ 50s delay	D	32	0.78
NE 8 th Street & NE Olney Avenue	Signalized	≤ 1.0 v/c	C	33	0.92
NE 8 th Street & NE Revere Avenue	AWSC	≤ 50s delay	F	121	1.18

^A AWSC = All-way stop control

Bold and Red indicates failing to meet ODOT or City of Bend standards.

Queueing

Table 3 summarizes the worst 95th percentile queue for each approach of the study intersections and for NE 3rd Street (US 20), rounded to the nearest 25 feet. Most of the queues are well short of the next nearest intersection. The 95th percentile queues for westbound NE Olney Avenue/ NE 3rd Street spills back beyond 4th Street today. Southbound queues at NE 8th Street at NE Revere Avenue spill back beyond NE Quimby Avenue but do not extend to NE Olney Avenue. This was consistent with field observations.

Table 3: Existing (2021) PM Peak Hour Queueing (95th Percentile / Average)

Intersection	Control ^A	Northbound	Eastbound	Westbound	Southbound
NE 3 rd Street & NE Revere Avenue	Signal	500 / 300	425 / 250	225 / 150	325 / 225
NE 3 rd Street & NE Olney Avenue	Signal	400 / 275	500 / 275	>400 / >250	325 / 175
NE 4 th Street & NE Revere Avenue	AWSC	250 / 125	225 / 125	400 / 175	200 / 100
NE 4 th Street & NE Olney Avenue	AWSC	100 / 75	175 / 100	250 / 150	125 / 75
NE 8 th Street & NE Revere Avenue	AWSC	425 / 200	125 / 75	100 / 50	625 / 300
NE 8 th Street & NE Olney Avenue	Signal	550 / 300	375 / 225	400 / 200	350 / 200

^A AWSC = All-way stop control

Bold and Red indicates queue spillback to the next major intersection or exceed 800 feet.

Safety Evaluation

The safety evaluation includes the most recent available six years of crash data, from 2015 to 2020. The project reviewed six years of crash data, rather than the typical five, due to the change in traffic volumes in 2020 because of the COVID 19 pandemic. The information is summarized in the following sections, with tables for intersection crashes by severity and 90th percentile crash rate comparison.

The observed crash rate for intersections is a function of the number of crashes and the annual average daily traffic (AADT). The crash rate (crashes per million entering vehicles) for the study intersection was compared to a critical crash rate (90th percentile crash rate of similar intersections throughout the state).²

The crashes that occurred at the study intersections are summarized in Table 4. While there were no fatal crashes at any of the intersections, there was a turning crash that resulted in an incapacitating injury at NE 8th Street and NE Olney Avenue in 2017. There was one recorded pedestrian crash at NE 4th Street and NE Revere Avenue, in 2016, that resulted in non-incapacitating injury and no bicyclist-involved crashes reported at any of the study intersections.

Table 4: Intersection Crashes by Severity (2015-2020)

Intersection	Severity					Total
	Fatal	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	Property Damage Only	
NE 4 th Street & NE Revere Avenue	0	0	3	3	9	15
NE 4 th Street & NE Olney Avenue	0	0	1	4	5	10
NE 8 th Street & NE Revere Avenue	0	0	1	6	8	15
NE 8 th Street & NE Olney Avenue	0	1	2	12	12	27
Total	0	1	7	25	34	67

As listed in Table 5, the intersections of NE 4th Street and NE Revere Avenue and NE 8th Street and NE Revere Avenue have an observed crash rate higher than the 90th percentile crash rate of similar sites in Oregon.

² Obtained from Oregon Department of Transportation's *Analysis Procedures Manual*, Exhibit 4-1

Table 5: 90th Percentile Crash Rate Comparison (2015-2020)

Intersection	Total Crashes	90 th Percentile Crash Rate	Observed Crash Rate	Observed > 90 th Rate?
NE 4 th Street & NE Revere Avenue	15	0.41	0.43	Yes
NE 4 th Street & NE Olney Avenue	10	0.41	0.37	No
NE 8 th Street & NE Revere Avenue	15	0.41	0.42	Yes
NE 8 th Street & NE Olney Avenue	27	0.58	0.52	No

Pedestrian and Bike Network

The following text describes existing pedestrian and bicycle conditions within the general study area.

NE 4th Street Corridor

The NE 4th Street corridor, south of the NE 4th Street and NE Revere Avenue intersection, has bike sharrows and sidewalks with curb ramps on both sides of the street. North of the NE 4th Street and NE Revere Avenue intersection, the corridor has north- and south-traveling bike lanes and a sidewalk on the east side of the street. The bike lanes are not buffered from the travel lane. NE 4th Street is identified as a part of the LSN, as shown in Figure 6 above.

NE 8th Street Corridor

The NE 8th Street corridor has no bike lanes. Both sides of the road have sidewalks, except for a small unpaved section on the southeast side of the NE 8th Street and NE Revere Avenue intersection. The sidewalks at the intersections have curb ramps with truncated domes.

NE Revere Avenue Corridor

The NE Revere Avenue corridor has east- and west-traveling bike lanes, and sidewalks with curb ramps, but no truncated domes, along the north side of the corridor between the study corridors, NE 8th Street and NE 4th Street. West, past the NE 4th Street and NE Revere Avenue intersection, sidewalks with curb ramps and truncated domes are along both sides of the road and there are no bike lanes. The bike lanes begin 250 feet east of the NE 4th Street and NE Revere Avenue intersection. The bike lanes are not buffered from the travel lane.

NE Olney Avenue Corridor

The NE Olney Avenue corridor has bike lanes and sidewalks with curb ramps and truncated domes along both sides of the corridor. The bike lanes are not buffered from the travel lane. NE Olney Avenue (west of NE 6th Street) and NE Norton Avenue (east of NE 6th Street) is identified as a Key Walking and Bicycling Route. East of 6th Street, there are large retaining walls along NE Olney Avenue that make widening NE Olney Avenue to accommodate a Key Route extremely challenging and costly. Therefore, the Key Route uses NE 6th Street to connect to NE Norton Avenue east of NE 6th Street.

Access Analysis

The four figures below show each of the study intersections and access points (driveways) near the intersections.

NE 4th Street and NE Olney Avenue

There are two driveways to the two different private businesses on the southwest corner are located within 100 feet of the intersection (see Figure 8). One driveway is along NE Olney Avenue and the other driveway is along NE 4th Street. As these are single entrance and exits to these businesses with no infrastructure for relocation, they will remain in their existing locations.



Figure 8: Access Analysis – NE 4th Street & NE Olney Avenue (Source: Google Earth)

NE 4th Street and NE Revere Avenue

There are two driveways to the two different private businesses are located with approximately 100 feet of the intersection (see Figure 9):

- The driveway along NE Revere Avenue is a single entrance.
- The driveway along NE 4th Street is one of many for the Albertsons grocery store. However, this driveway provides access to the nearby loading dock. An understanding of site circulation will be needed before potentially modifying this access.



Figure 9: Access Analysis – NE 4th Street & NE Revere Avenue (Source: Google Earth)

NE 8th Street and NE Olney Avenue

There are five driveways within 100 feet of the intersection, as shown in Figure 10:

- Two are for the same private business on the northeast corner and are located within 100 feet of the intersection. One driveway is along NE 8th Street (1) and the other is along NE Olney Avenue (2).
- Two driveways (3, 4) are for individual homes along the southeast corner of the intersections.
- One driveway serving two homes is located on the southwest corner, along NE 8th Street (5).



Figure 10: Access Analysis – NE 8th Street and NE Olney Avenue (Source: Google Earth)

NE 8th Street and NE Revere Avenue

There are three driveways within 100 feet of the intersection (see Figure 11):

- The driveway is along NE 8th Street on the northwest corner of the intersection is the only driveway to a residential home, therefore it cannot be closed.
- The two driveways at the southwest corner of the intersection are close to each other and serve the same residential home.



Figure 11: Access Analysis – NE 8th Street and NE Revere Avenue (Source: Google Earth)

Equity Evaluation

The Bend Transportation Bond Oversight Committee (TBOC) has Project Evaluation Criteria³, including an evaluation for equity. The following scores listed in Table 6 were provided for the equity evaluation criteria for this project. There is expected to be a moderate positive impact on equity with the implementation of these intersection improvement projects.

Table 6: Equity Evaluation Results for NE 4th Street and NE 8th Street Intersection Improvements

Equity Evaluation Criteria	Score	Notes
Transportation Access for Underserved Populations	●	Scored by TBOC
Transportation impacts on the community	●	Scored by TBOC
Reduce pollution of Bend's air and water, with a focus on the impacts to vulnerable populations	○	Limited impact on reducing pollution
Access to key destinations	◐	Minor improvement to connectivity for cyclists to/from commercial area on 3 rd Street

- The project clearly supports the criterion and/or makes substantial improvements in the criteria category
- ◐ The project partially supports the criterion and/or makes moderate improvements in the criteria category.
- The project does not support the intent of, provides minor or incidental benefit and/or negatively impacts the criteria category.

³ https://bend.granicus.com/MetaViewer.php?view_id=18&event_id=676&meta_id=51774

2040 No Build Conditions

Future Traffic Volumes

The regional travel demand model was used to forecast growth in traffic volumes to 2040. From the model, there is significant traffic growth expected in the area in the future. NE Olney Avenue is one of the few crossings of the Deschutes River and provides a connection to St. Charles Hospital, while NE Revere Avenue provides a direct connection to US 97. In addition, NE 3rd Street (US 20), could see an increase in traffic if ramp metering is implemented along the Bend Parkway (US 97) as planned within the Bend Parkway Plan. Denser development is also expected in the Bend Central District in the future, which includes NE 4th Street.

Traffic volumes along NE 4th Street are forecasted to grow by approximately 40 to 45 percent by 2040, while volumes along NE 8th Street are projected to grow by approximately 20 to 25 percent. Traffic on NE Revere Avenue is also projected to grow by 20 to 25 percent, while NE Olney Avenue has a forecasted growth of 55 to 60 percent. Figure 12 shows the future (2040) PM Peak Hour traffic volumes for each of the study intersections.

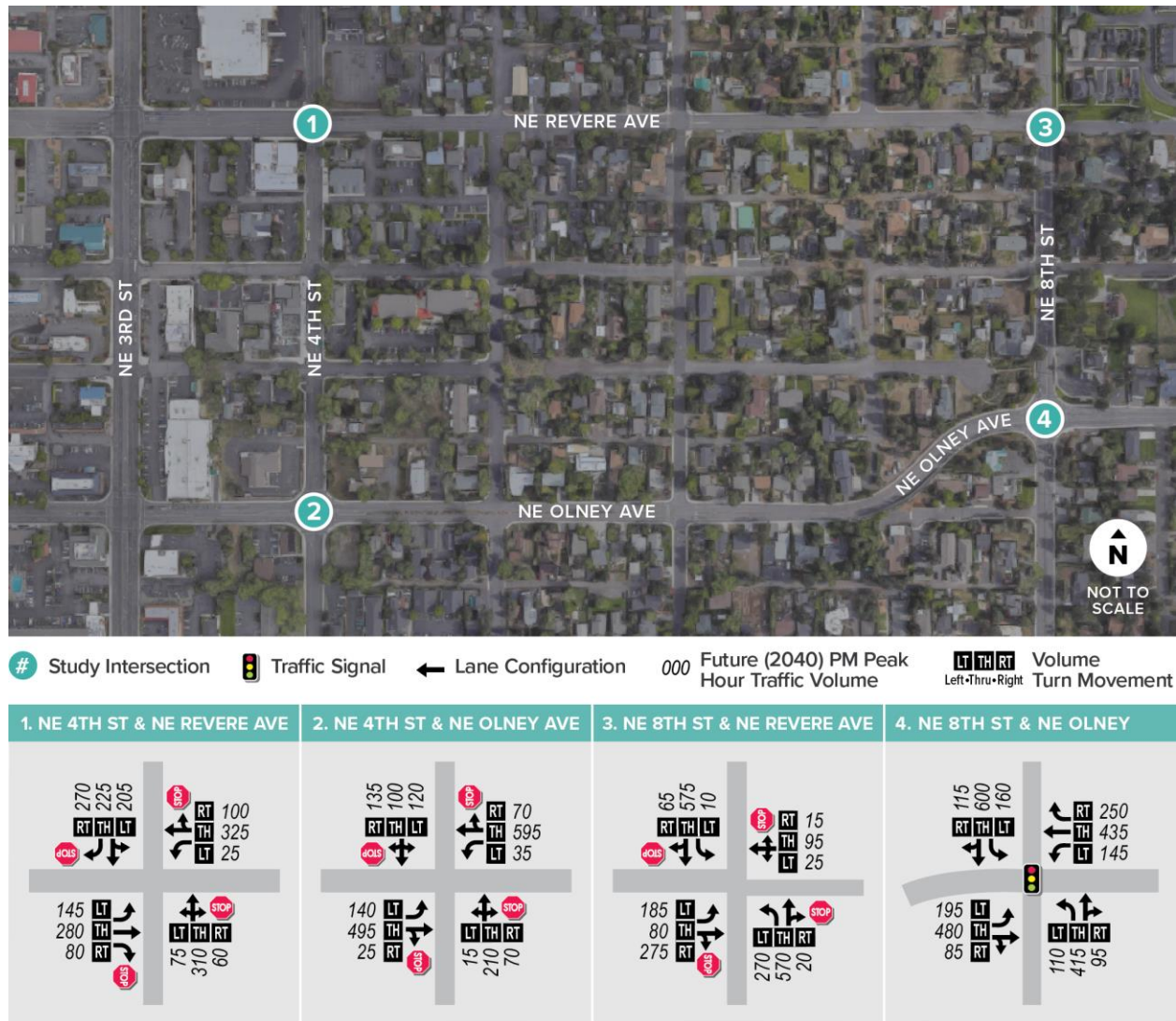


Figure 12: Future (2040) PM Peak Hour Traffic Volumes

Intersection Operations Results

Table 7 shows the future (2040) No Build intersection operations for all four study intersections, as well as the two intersections at NE 3rd Street. All intersections in the future no build (2040) except NE 3rd Street and NE Revere Avenue, fail to meet ODOT and City of Bend mobility standards for all-way stop control and signalized intersections. See Appendix B.2 for future no build intersection operations.

Table 7: Future No Build (2040) PM Peak Hour Intersection Operations

Intersection	Control ^A	Mobility Standards	Existing (2021)			Future No Build (2040)		
			LOS	Delay (s)	v/c ^B	LOS	Delay (s)	v/c ^B
NE 3 rd Street & NE Revere Avenue	Signalized	≤ 0.90 v/c	C	30	0.70	D	36	0.86
NE 3 rd Street & NE Olney Avenue	Signalized	≤ 0.90 v/c	D	36	0.74	E	71	1.05
NE 4 th Street & NE Revere Avenue	AWSC	≤ 50s delay	F	130	1.15	F	214	1.47
NE 4 th Street & NE Olney Avenue	AWSC	≤ 50s delay	D	32	0.78	F	320	1.70
NE 8 th Street & NE Olney Avenue	Signalized	≤ 1.0 v/c	C	33	0.92	E	64	1.10
NE 8 th Street & NE Revere Avenue	AWSC	≤ 50s delay	F	121	1.18	F	253	1.54

^A AWSC = All-way stop control

^B v/c = Volume-to-capacity ratio, or the degree of saturation an intersection experiences, otherwise defined as the sufficiency of an intersection to accommodate the vehicular demand.

Bold and Red indicates failing to meet ODOT or City of Bend standards.

Queueing

Table 8 summarizes the longest 95th percentile queue for each approach of the study intersections, rounded to the nearest 25 feet. Given the proximity to NE 3rd Street (US 20), the analysis also considered any future potential queuing impacts between NE 3rd Street and NE 4th Street. The impact of queuing from NE 3rd Street and NE Olney Avenue is significant in the future, with many queues spilling through other intersections.

Table 8: Future (2040) PM Peak Hour Queuing (95th Percentile / Average)

Intersection	Control ^A	Northbound	Eastbound	Westbound	Southbound
NE 3 rd Street & NE Revere Avenue	Signal	575 / 450	400 / 250	300 / 150	475 / 300
NE 3 rd Street & NE Olney Avenue	Signal	>800 / >800	>800 / >800	>450 / >350	>800 / 500
NE 4 th Street & NE Revere Avenue	AWSC	>800 / 550	225 / 150	>800 / 700	>800 / 700
NE 4 th Street & NE Olney Avenue	AWSC	350 / 125	375 / 200	>800 / >800	300 / 125
NE 8 th Street & NE Revere Avenue	AWSC	775 / 425	175 / 100	100 / 75	>800 / >800
NE 8 th Street & NE Olney Avenue	Signal	>800 / 500	600 / 325	>800 / >800	500 / 300

^A AWSC = All-way stop control

Bold and Red indicates a queue spillback to the next major intersection or exceed 800 feet.

System Level Needs and Constraints Summary

- Queues from NE 3rd Street and NE Olney Avenue intersections spill back into NE 4th Street and NE Olney in the future.
- Transit routes are planned along the NE 4th Street and NE 8th Street corridors and should be accommodated in any intersection design, including safe walking and biking access to transit stops.
- A section of NE Olney Avenue, west of NE 6th Street, has been identified as a Key Walking and Biking Route.
- NE 4th Street is part of the LSN. NE Revere Avenue and NE Olney Avenue, west of NE 6th Street, are also part of the LSN.

Intersection Level Needs and Constraints Summary

- There is limited right-of-way today at NE 4th Street and NE Olney Avenue due to retaining walls on all four corners of the intersection.
- There is limited right-of-way today at NE 8th Street and NE Olney Avenue due to retaining walls along the west leg and houses adjacent to the intersection.
- Both study intersections along NE Revere Avenue (NE 4th Street and NE 8th Street) have an observed crash rate higher than the 90th percentile crash rate of similar sites in Oregon.
- Intersection operations at all study intersections, except NE 3rd Street and NE Revere Avenue, fail to meet City of Bend standards in the future (2040).
- Without any additional improvements, 95th percentile queuing in the future (2040) is significant at all study intersections, with many queues spilling back into other intersections.

NE 4th Street Alternatives Evaluation

The following section describes an evaluation of alternatives along NE 4th Street at NE Revere Avenue and NE Olney Avenue. These intersections are discussed together due to their proximity to NE 3rd Street, which results in significant queuing impacts on the NE 4th Street intersections. Both intersections also have similar surrounding land use contexts, with a mix of commercial and residential buildings. Therefore, similar improvements to the intersections will likely need to be considered along NE 4th Street.

Alternatives Description

Two alternatives were considered for the intersections along NE 4th Street: traffic signals and roundabouts.

Traffic Signal Concepts

Signalized intersection concepts are shown in Appendix C to highlight the potential right-of-way footprint needed at both intersections. At NE 4th Street and NE Revere Avenue, the conceptual design depicts:

- Approximately 200-foot left turn lanes on the north and south legs to provide the opportunity for protected left turn phases and an optional right turn lane on the north leg. The east and west legs would retain their existing configuration.
 - This would require additional right-of-way and likely impact the parking lot in the northwest corner.
 - Adding left turn lanes on the northbound and southbound approaches would help manage vehicle queuing and allow for protected pedestrian crossings of the east and west legs.
- The signalized concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements. The concept figure shows an example of how some of these improvements could be implemented but additional design and community feedback is still needed.

At NE 4th Street and NE Olney Avenue, the conceptual design includes the following considerations:

- The east, west, and south legs of the intersection would retain their existing configurations. Approximately 200-foot right turn lane added to the north leg of the intersection to address queuing issues (discussed in more detail below in the intersection operations performance).
 - This would require additional right-of-way and impacts to the existing retaining walls. Due to an existing parking lot and retaining wall on the northwest corner of the intersection, the concept shows the road widened to the east to reduce potential impacts.
- Similar to the NE 4th Street and NE Revere Avenue intersection, the signalized concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements. The concept figure shows an example of how some of these improvements could be implemented but additional design and community feedback is still needed.

- As there is a CET bus stop near the NE 4th Street and NE Olney Avenue intersection that will be retained for Route 5, the intersection improvement should accommodate the stop somewhere near its existing location.

Cost estimates were developed based on general knowledge from the consultants of recent costs for the design and construction of similar facilities. It is expected that a signalized intersection would cost approximately \$1.5 to \$2.5 million per intersection. These cost estimates should be refined as design concepts are further advanced to include additional detail, including the need for and cost of right-of-way and new retaining walls.

Roundabout Concepts

The single-lane roundabout concepts are shown in Appendix C to highlight the potential right-of-way footprint needed at both intersections. Due to the westbound queuing impact from NE 3rd Street, it is most likely that in the long term, the roundabouts at both intersections would need to be signalized (not shown in the concepts) to allow westbound vehicles to clear through the intersection and avoid backups back to NE 3rd Street (discussed in more detail below in the intersection operations performance).

The NE 4th Street and NE Revere Avenue single-lane roundabout concept includes the following design features:

- 130 feet in diameter, with 20-foot entry and exit lanes on all approaches and 14-foot offsets for sidewalk and buffer.
- The concept is shifted north to have as little impact as possible on existing structures on the southwest and southeast corners.

The NW 4th Street and NE Olney Avenue roundabout concept includes the following design features:

- 88 feet in diameter to fit approximately within the existing retaining walls. It has 14-foot entry and exit lanes on all approaches, with a fully mountable splitter and center island (meeting the definition of a mini roundabout in the 2024 City of Bend Roundabout Design Manual⁴).
- The northeast and southeast corners have significant grade drops behind the sidewalk with existing retaining walls, which could significantly increase costs. Note that pedestrians are currently protected from the existing grade drop by a fence.

Cost estimates were developed based on input from the City of Bend on recent costs for the design and construction of similar facilities. It is expected that a single lane roundabout would cost approximately \$2.5 to \$3.5 million while signalizing a roundabout would cost approximately \$0.5 to \$1.0 million, for a total of \$3.0 to \$4.5 million per intersection. These cost estimates should be refined as design concepts are further advanced to include additional detail, including the need for and cost of right-of-way and new retaining walls.

Since the initial development of this report in 2023, the City of Bend has released an updated Roundabout Design Manual. Within the manual, it defines a mini roundabout and where mini roundabouts should be considered in Bend (primarily low-speed and low-volume corridors). Due to the higher traffic volumes and functional classification of the streets, a mini roundabout is not recommended for evaluation for these intersections based on the City's *Intersection Control Evaluation Scoping Form* in the Design Manual.

⁴City of Bend, *Roundabout Design Manual* (2024)

Alternatives Performance

Safety

In general, both intersection treatments are expected to enhance safety compared to the existing all-way stop controlled intersections. Signalized intersections have the potential to reduce angle crashes by up to 67 percent⁵, but can increase rear end crashes by up to 143 percent⁶. While there is an increase in rear end crashes, angle crashes are more likely to cause severe injury than rear end crashes. A signal can also provide an opportunity for enhanced pedestrian and bicycle improvements. This could include signal timing treatments such as leading pedestrian intervals (LPIs), which give people walking the opportunity to enter the crosswalk 3 to 7 seconds before vehicles are given a green indication. The addition of leading pedestrian intervals can reduce crashes with pedestrians and bicyclists by up to 37 percent⁷.

Roundabouts have the potential to reduce injury crashes by up to 82 percent⁸ from all-way stop control intersections. Roundabouts can further aid in controlling vehicle speeds and provide a refuge island for people walking and biking, which can improve walking and bicycling levels of traffic stress.

Existing and Future Intersection Operations and Queuing

Table 9 lists the operational results of a single-lane roundabout and a signalized intersection, at NE 4th Street and NE Revere Avenue and NE 4th Street and NE Olney Avenue, as compared to no-build conditions. See Appendix B.3 for Alternatives Intersection Operations.

At NE 4th Street and NE Revere Avenue, the existing and future all-way stop control does not meet City of Bend mobility standards for delay (50 seconds). Both the signalized intersection and the single-lane roundabout meet mobility standards, with the single-lane roundabout operating with slightly less delay than the signalized intersection. Note the results shown in Table 9 do not consider queueing back from NE 3rd Street and a mini roundabout may operate with more delay than the standard roundabout that was analyzed.

At NE 4th Street and NE Olney Avenue, the all-way stop control with future traffic volumes, does not meet City of Bend mobility standards for delay (50 seconds). Both the signalized intersection and the roundabout meet mobility standards, with the roundabout operating with slightly less delay than the signalized intersection. Note the results shown in Table 9 do not consider queueing impacts from NE 3rd Street.

⁵ ODOT Crash Reduction Factor List, 2020, CMF ID: 323

⁶ ODOT Crash Reduction Factor List, 2020, CMF ID: 324

⁷ ODOT Crash Reduction Factor List, 2020, CMF Clearinghouse, Safety Effectiveness of Leading Pedestrian Intervals Using Empirical Bayes Method

⁸ ODOT Crash Reduction Factor List, 2020, CMF ID: 228

Table 9: Intersection Operations at both NE 4th Street intersections

	Year	Control ^A	P.M. Peak Hour Results		
			LOS	Delay (s)	v/c
NE 4 th Street and NE Revere Avenue	Existing (2021)	All-way stop control	F	130	1.15
		Signalized intersection	B	18	0.77
		Single-lane roundabout ^B	A	9	0.51
	Future (2040)	All-way stop control	F	214	1.47
		Signalized intersection	C	23	0.87
		Single-lane roundabout ^B	B	14	0.75
NE 4 th Street and NE Olney Avenue	Existing (2021)	All-way stop control	D	32	0.78
		Signalized intersection	A	10	0.61
		Single-lane roundabout ^B	A	7	0.38
	Future (2040)	All-way stop control	F	320	1.70
		Signalized intersection	B	16	0.84
		Single-lane roundabout ^B	B	13	0.71

^A Overall intersection LOS and delay reported for all-way stop control, signalized, and roundabout intersections. Worst Major Street/Minor Street v/c reported for all-way stop control intersections. Worst approach v/c reported for signalized and roundabout intersections.

^B The single-lane roundabouts overstate available capacity, as they do not take the significant queuing impacts from NE 3rd Street into consideration. The analysis also assumes a full-size roundabout, while NE 4th Street and NE Olney Avenue would operate more like a mini-roundabout.

Bold and Red indicates failing to meet City of Bend standards.

Table 10 compares the existing (2021) and future (2040) 95th percentile and average queues with an all-way stop control, a signalized intersection, and a single-lane roundabout at NE 4th Street and NE Revere Avenue. Note the results shown in Table 10 do not consider queuing back from NE 3rd Street with the single-lane roundabout, while the all-way stop control and signalized intersection do. This table shows that a signalized intersection will have queuing impacts in the future, but would be more feasible than a roundabout, which would be unable to operate at the necessary capacity for the area. The signalized intersection queuing can be improved with coordination of the signal at NE 3rd Street and NE Revere Avenue. Note that a sensitivity test was conducted that indicated the southbound right turn lane at the signalized intersection would be optional and removing that right turn lane would not result in a significant operational impact in the 20-year planning horizon.

Table 10: Queuing (95th Percentile / Average) NE 4th Street and NE Revere Avenue

Year	Control	Northbound	Eastbound	Westbound	Southbound
Existing (2021)	All-way stop control	250 / 100	225 / 125	400 / 175	200 / 100
	Signalized intersection	175 / 100	200 / 100	250 / 150	125 / 75
	Single-lane roundabout ^A	50 / NA	50 / NA	50 / NA	75 / NA
Future (2040)	All-way stop control	>800 / 550	225 / 150	>800 / 700	>800 / 700
	Signalized intersection	275 / 150	200 / 125	300 / 175	175 / 75
	Single-lane roundabout ^A	100 / NA	100 / NA	75 / NA	275 / NA

^A The single-lane roundabouts overstate available capacity, as they do not take the significant queuing impacts from NE 3rd Street into consideration.

Bold and Red indicates queue spillback to the next major intersection or exceed 800 feet.

Table 11 compares the existing (2021) and future (2040) 95th percentile and average queues with an all-way stop control, a signalized intersection, and a single-lane roundabout at NE 4th Street and NE Olney Avenue. The single-lane roundabout overstates available capacity, as it does not take the significant queuing impacts from NE 3rd Street into consideration. This table shows that a signalized intersection will have queuing impacts in the future, but would be more feasible than a roundabout, which would be unable to operate at the necessary capacity for the area. The signalized intersection queuing can be improved with coordination of the signal at NE 3rd Street and NE Olney Avenue. Note that a sensitivity test was conducted that indicated the southbound right turn lane at the signalized intersection would not be needed in the near-term but would provide additional queue storage within the 20-year planning horizon as congestion from NE 3rd Street constantly spills back to NE 4th Street.

Table 11: Queuing (95th Percentile / Average) NE 4th Street and NE Olney Avenue

Year	Control	Northbound	Eastbound	Westbound	Southbound
Existing (2021)	All-way stop control	100 / 75	175 / 100	250 / 150	125 / 75
	Signalized intersection	125 / 75	175 / 75	300 / 150	125 / 75
	Single-lane roundabout ^A	25 / NA	50 / NA	300 / 150 ^A	25 / NA
Future (2040)	All-way stop control	350 / 125	375 / 200	>800 / >800	300 / 125
	Signalized intersection	375 / 175	300 / 150	>800 / >800	450 / 200
	Single-lane roundabout ^A	50 / NA	150 / NA	>800 / >800 ^A	50 / NA

^A The single-lane roundabout results understate queuing, as they do not take the significant queuing impacts from NE 3rd Street into consideration. Westbound queue results were adjusted to match signalized intersection queuing to better take NE 3rd Street queuing into consideration.

Bold and Red indicates queue spillback to the next major intersection or exceed 800 feet.

NE 4th Street Findings and Recommendations

NE 3rd Street causes significant queuing back through the NE 4th Street study intersections along NE Olney Avenue. A roundabout would be frequently blocked by the westbound traffic stopped at NE 3rd Street, possibly blocking access at the roundabout and leading to queuing back into the NE 3rd Street intersection. If a roundabout was installed, it would likely require signalization on all approaches to ensure the intersections remain clear. Additionally, the traffic signals can be coordinated with the NE 3rd Street traffic signals to improve queuing and traffic flow in the area.

Furthermore, a roundabout would have significant right-of-way impacts, potentially necessitating a rebuild of the four retaining walls at the NE 4th Street and NE Olney Avenue intersection. Traffic signals along NE 4th Street would have a smaller right-of-way impact on existing retaining walls, reducing the overall cost for improvements. With the budget allocated for the improvements to the four intersections, it would not be feasible to build four roundabouts given the right-of-way constraints. Therefore, signalized intersections are recommended along NE 4th Street.

At NE 4th Street and NE Revere Avenue:

- Figure 1 shows the approximate intersection footprint. It is recommended along the north and south legs that an approximately 200-foot left turn lane be constructed to provide the opportunity for protected left turn phases. The east and west legs would retain their existing lane configuration.
- Figure 1 also includes an optional right turn lane on the north leg. This could be constructed if needed in the future to reduce queuing and/or to support implementation of a particular pedestrian or bicyclist crossing treatment.

- Enhanced intersection lighting is recommended at this intersection to address a history of crashes that occur in the dark, as identified by the Bend Transportation Safety Action Plan (TSAP).
- The signalized concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements. Figure 1 shows an example of how some of these improvements could be implemented but additional design and community feedback is still needed.

At NE 4th Street and NE Olney Avenue:

- Figure 2 shows the approximate intersection footprint. The east, west, and south legs of the intersection would retain their existing configurations. On the north leg, a 200-foot right turn lane is recommended to help address future queueing issues on 4th Street. While not needed in the near-term, the right turn lane will help provide queue storage in the 20-year planning horizon as 3rd Street congestion spills back to 4th Street.
 - Given the right-turn lane is not needed in the near-term, the added turn lane could be added in the future when needed to address congestion issue and/or to support implementation of a particular pedestrian or bicyclist crossing treatment.
- The signalized concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements. Figure 1 shows an example of how some of these improvements could be implemented but additional design and community feedback is still needed.
- As there is a CET bus stop near the NE 4th Street and NE Olney Avenue intersection that will be retained for Route 5, the intersection improvement should accommodate the stop somewhere near its existing location.

8th Street Alternatives Evaluation

The following section describes an evaluation of alternatives along NE 8th Street at NE Revere Avenue and NE Olney Avenue. These intersections are discussed together due to their proximity and similar surrounding land use contexts, with primarily residential buildings. Therefore, similar improvements will likely need to be considered along NE 8th Street.

Alternatives Description

Two alternatives were considered for the intersections along NE 8th Street: traffic signals and roundabouts.

Signals

Signalized intersection concepts are shown in Appendix D to highlight the potential right-of-way footprint needed at both intersections. At NE 8th Street and NE Revere Avenue, the conceptual design includes the following parameters:

- A through-right and left turn lanes on all approaches.
- The east leg of the intersection is shown to be reconstructed to be in-line with the west leg of the intersection, requiring additional right-of-way and likely impacting a few existing trees, but no structures.
- While not shown in the concept, the signalized concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements.

At NE 8th Street and NE Olney Avenue, the conceptual design includes the following parameters:

- An added 150-foot right turn lane be added to the north leg of the intersection. The east, west, and south legs of the intersection would retain their existing configurations.
 - This improvement is recommended due to significant queuing impacts from right-turning vehicles that are headed southbound.
 - This would require additional right-of-way, likely impacting the community park on the northwest corner of the intersection.
- Similar to NE 8th Street and NE Revere Avenue, the concept design could include a variety of possible multimodal improvements for pedestrians and bicyclists, such as pedestrian and bicycle detection, bike boxes, leading pedestrian intervals, and ADA curb ramp improvements.

Cost estimates were developed based on general knowledge from the consultants of recent costs for the design and construction of similar facilities. It is expected that a signalized intersection would cost approximately \$1.0 to \$2.0 million per location. These cost estimates should be refined as design concepts are further advanced to include additional detail, including the need for and cost of right-of-way.

Roundabouts

The roundabout concepts are shown in Appendix D to highlight the potential right-of-way footprint needed at both intersections. At NE 8th Street and NE Revere Avenue, the conceptual design includes the following parameters:

- A single-lane roundabout that is 130 feet in diameter, with 20-foot entry and exit lanes on all approaches and 14-foot offsets for sidewalk and buffer.
- The roundabout is shown shifted north to have as little impact as possible on existing structures on the southwest and southeast corners.

Three different roundabout designs were evaluated at NE 8th Street and NE Olney Avenue:

- A single lane roundabout, centered on existing intersection that is 130-feet in diameter, accommodates a WB-67 truck, with 20-foot entry and exit lanes on all approaches.
- A partial multi-lane roundabout with right turn slip lanes, shifted north to minimize southeast and southwest building impacts that is 150-feet in diameter, accommodates a WB-50 truck, with multi-lane entry on north, east, and west approaches, single 20-foot exits on all approaches
- A full multi-lane roundabout, shifted north to minimize southeast and southwest building impacts that is 165-feet in diameter, accommodates a WB-67 truck, dual lane entry and exits on all approaches.

When the roundabout is centered on the intersection, there are right-of-way impacts on all corners, with one structure impacted on the southeast corner. When the roundabout is shifted north, it further impacts a private business parking lot on the northeast, a community park on the northwest, and part of the structure to the southeast in some concepts.

Cost estimates were developed based on input from the City of Bend on recent costs for the design and construction of similar facilities. It is expected that a single lane roundabout would cost approximately \$2.5 to \$3.5 million while a multi-lane roundabout would cost between \$5.0 to \$6.0 million. These cost estimates should be refined as the design concepts are further advanced to include additional detail, including the need for and cost of right-of-way.

Since the initial development of this report in 2023, the City of Bend has released an updated Roundabout Design Manual. Within the manual, it adds the concept of a mini roundabout for use on low-speed corridors. Due to the higher traffic volumes and functional classification of the streets, a mini roundabout is not recommended for evaluation at these intersections based on the City's *Intersection Control Evaluation Scoping Form* in the Design Manual.

Alternatives Performance

Safety

In general, both intersection treatments are expected to enhance safety compared to the existing all-way stop controlled intersection at NE 8th Street and NE Revere Avenue. Signalized intersections have the potential to reduce angle crashes by up to 67 percent⁹, but can increase rear end crashes by up to 143 percent¹⁰. While there is an increase in rear end crashes, angle crashes are more likely to cause severe injury than rear end crashes. A signal can also provide an opportunity for enhanced pedestrian and bicycle improvements. This could include signal timing treatments such as leading pedestrian intervals (LPIs), which give people walking the opportunity to enter the crosswalk 3 to 7 seconds before vehicles are given a green indication. The addition of leading pedestrian intervals can reduce crashes with pedestrians and bicyclists by up to 37 percent¹¹.

Roundabouts have the potential to reduce injury crashes by up to 82 percent¹² from all-way stop control intersections. Roundabouts can further aid in controlling vehicle speeds and provide a refuge island for people walking and biking, which can improve walking and bicycling levels of traffic stress.

Existing and Future Intersection Operations and Queuing

Table 12 lists the operational results of the signalized intersection and roundabouts at NE 8th Street and NE Revere Avenue and NE 8th Street and NE Olney Avenue as compared to no-build conditions.

The NE 8th Street and NE Revere Avenue intersection with the signalized and roundabout configurations operate with significantly less delay than future no-build conditions and would meet City of Bend mobility standards.

Two of the five intersection configurations (signalized intersection and full multi-lane roundabout) for the NE 8th Street and NE Olney Avenue intersection meet City of Bend mobility standards in the future. The full multi-lane roundabout has less delay and lower v/c ratio than the signalized intersection with the southbound right turn lane. See Appendix B.3 for Alternatives Intersection Operations.

⁹ ODOT Crash Reduction Factor List, 2020, CMF ID: 323

¹⁰ ODOT Crash Reduction Factor List, 2020, CMF ID: 324

¹¹ ODOT Crash Reduction Factor List, 2020, CMF Clearinghouse, Safety Effectiveness of Leading Pedestrian Intervals Using Empirical Bayes Method

¹² ODOT Crash Reduction Factor List, 2020, CMF ID: 228

Table 12: Intersection Operations at both intersections on NE 8th Street

	Year	Control ^A	P.M. Peak Hour Results		
			LOS	Delay (s)	v/c
NE 8 th Street and NE Revere Avenue	Existing (2021)	All-way stop control	F	121	1.18
		Signalized intersection	C	23	0.51
		Single-lane roundabout	B	12	0.69
	Future (2040)	All-way stop control	F	253	1.54
		Signalized intersection	C	27	0.63
		Single-lane roundabout	C	17	0.82
NE 8 th Street and NE Olney Avenue	Existing (2021)	Signalized intersection	D	36	0.74
		Signalized intersection (with southbound right turn)	C	31	0.86
		Single-lane roundabout	C	25	0.88
		Partial multi-lane roundabout (right turns)	C	17	0.82
		Full multi-lane roundabout	B	11	0.52
	Future (2040)	Signalized intersection	D	47	0.96
		Signalized intersection (with southbound right turn)	D	42	0.96
		Single-lane roundabout	F	75	1.14^B
		Partial multi-lane roundabout (right turns)	E	38	1.02^C
		Full multi-lane roundabout	C	21	0.82

^A Overall intersection LOS and delay reported for all-way stop control, signalized, and roundabout intersections. Worst Major Street/Minor Street v/c reported for all-way stop control intersections. Worst approach v/c reported for signalized and roundabout intersections.

^B Three legs have an approach v/c > 1.0 (Southbound approach v/c = 1.14, westbound approach v/c = 1.11, eastbound approach v/c = 1.05). All others less than v/c of 1.0.

^C One movement has a v/c > 1.0 (eastbound through/left movement v/c = 1.02). All others less than v/c of 1.0.

Bold and Red indicates failing to meet City of Bend mobility standards ≤ 1.0 v/c (signalized and roundabout).

Table 13 compares the existing (2021) and future (2040) 95th percentile and average queues with an all-way stop control, a signal and a single-lane roundabout at NE 8th Street and NE Revere Avenue. The 95th percentile queues along NE Revere Avenue are over 800 feet for east- and westbound traffic with the signalized intersection. Additionally, the 95th percentile queue for the southbound all-way stop control is over 625 feet in existing and over 800 feet in the future. These are significant queues as the traffic spills back through the next intersection. A single-lane roundabout has much shorter queues with existing and future volumes.

Table 13: Queuing (95th Percentile / Average) NE 8th Street and NE Revere Avenue

Year	Control	Northbound	Eastbound	Westbound	Southbound
Existing (2021)	All-way stop control	425 / 200	125 / 75	100 / 50	625 / 300
	Signalized intersection	300 / 150	325 / 175	150 / 75	350 / 200
	Single-lane roundabout	250 / NA	100 / NA	25 / NA	100 / NA
Future (2040)	All-way stop control	750 / 425	175 / 100	100 / 75	>800 / >800
	Signalized intersection	500 / 275	500 / 250	150 / 75	>800 / 600
	Single-lane roundabout	500 / NA	150 / NA	25 / NA	200 / NA

Bold and Red indicates queue spillback to the next major intersection or exceed 800 feet.

Table 14 compares the existing (2021) and future (2040) 95th percentile and average queues with an all-way stop control, signals and roundabouts with different lane configurations at NE 8th Street and NE Olney Avenue. With future volumes, a signalized intersection, a signalized intersection with a southbound right turn, and a single-lane roundabout result in significant queuing. A partial multi-lane roundabout and full multi-lane roundabout result in shorter queues that do not extend back to NE Revere Avenue or any other major intersections.

Table 14: Queuing (95th Percentile / Average) NE 8th Street and NE Olney Avenue

Year	Control	Northbound	Eastbound	Westbound	Southbound
Existing (2021)	Signalized intersection	550 / 300	375 / 225	400 / 200	350 / 200
	Signalized intersection (southbound right turn)	425 / 275	425 / 250	500 / 250	500 / 250
	Single-lane roundabout	175 / NA	175 / NA	400 / NA	325 / NA
	Partial multi-lane roundabout (right turns)	175 / NA	125 / NA	100 / NA	300 / NA
	Full multi-lane roundabout	75 / NA	75 / NA	100 / NA	100 / NA
Future (2040)	Signalized intersection	>800 / 500	600 / 325	>800 / >800	500 / 300
	Signalized intersection (southbound right turn)	500 / 325	>800 / 750	>800 / >800	775 / 450
	Single-lane roundabout	275 / NA	750 / NA	>800 / NA	>800 / NA
	Partial multi-lane roundabout (right turns)	300 / NA	550 / NA	200 / NA	525 / NA
	Full multi-lane roundabout	100 / NA	200 / NA	200 / NA	250 / NA

Bold and Red indicates queue spillback to the next major intersection or exceed 800 feet.

NE 8th Street Findings and Recommendations

The NE 8th Street and NE Revere Avenue intersection's current configuration of an all-way stop control does not meet City of Bend delay standards (50 seconds) with existing or future volumes. The NE 8th Street and NE Olney Avenue intersection does meet City of Bend standards for signalized intersections ($v/c < 1.0$) with existing and future volumes, although it is very close to failing in the future, but it results in significant queue spillback between major intersections.

Traffic operations at NE 8th Street and NE Revere Avenue are improved, and meets City of Bend standards, by the installation of either a signalized intersection (v/c of 0.63 in the future) or a single-lane roundabout (v/c of 0.82 in the future). However, NE 8th Street and NE Olney Avenue operations are expected to perform significantly better (less queueing in particular) with a roundabout than a signalized intersection. Given the safety and operational improvements associated with roundabouts, both intersections along NE 8th Street are recommended to include roundabouts.

At NE 8th Street and NE Revere Avenue, a single lane roundabout is recommended. Figure 3 shows a roundabout concept that includes:

- A single-lane roundabout that is 130 feet in diameter, designed to accommodate WB-50 trucks, with 18-foot entry and exit lanes on all approaches and 14-foot offsets for sidewalk and buffer. This concept will continue to be refined during design. The roundabout is shifted north to have as little impact as possible on existing structures on the southwest and southeast corners. This concept will continue to be refined during design to reduce potential right-of-way impacts.

At NE 8th Street and NE Olney Avenue intersection, a partial multilane roundabout with right turn slip lanes is recommended. Despite a full multi-lane roundabout performing the best operationally, the full multi-lane roundabout would have a significant right-of-way impact on many private properties and would be extremely costly given the retaining wall impacts on the west leg of the intersection. Instead, a partial multi-lane roundabout with right turn slip lanes will allow for improved operations along the corridor, reduce queuing spillback into other intersections and reduce the overall cost of the improvements to better fit within the project budget. Furthermore, NE 8th Street and NE Olney Avenue was identified as a top 10 percent site for equivalent property damage only in the Bend TSAP and a roundabout would improve safety at the intersection over the existing signalized intersection.

At NE 8th Street and NE Olney Avenue, Figure 4 shows an approximate partial multi-lane roundabout footprint, which includes:

- A partial multi-lane roundabout with right turn slip lanes, shifted north to minimize southeast and southwest building impacts.
- The roundabout concept shows a roundabout with 150-foot diameter that accommodates WB-50 trucks and has multi-lane entry on north, east, and west approaches, single 18-foot lane entry on the south approach, single 18-foot exits on all approaches, and 14-foot offsets for sidewalk and buffer. This concept will continue to be refined during design to reduce potential right-of-way impacts.